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STUDIES ON SEPARATION OF WEEVIL-INFESTED FROM NONINFESTED WHEAT BY FLOTATION

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SUMMARY

Samples of hard red winter wheat, with 12 percent moisture content and infested with the rice weevil, were immersed in solutions of sodium silicate with specific gravities ranging from 1.050 to 1.350, in detailed laboratory studies to separate weevil-infested from noninfested wheat by flotation. In solutions with specific gravities of 1.190 or below, about 50 to 70 percent of the infested kernels were separated from the grain sample without any sound kernels floating. At a specific gravity of 1.350, all infested kernels floated, but 64 percent of the sound kernels floated also. Each sample was X-rayed to determine the exact number of infested kernels contained in it.

When infested samples were immersed in a 2-layered liquid in which a sodium silicate solution with a specific gravity of 1.160 was floated on a methyl chloroform-kerosene solution with a specific gravity of 1.300, the top floating layer contained mostly kernels infested with advanced stages of larvae, the second floating layer contained a mixture of kernels infested with early-stage larvae and lightweight sound kernels. The nonfloating residue was nearly all sound kernels.

It is suggested that the immersion of samples of commercial wheat in a solution with a specific gravity somewhere between 1.190 and 1.050 could be used to give a fairly accurate estimate of the intensity of infestation present on the basis that if more than one kernel contains advanced-stage larvae, this fact would be evidenced by floating kernels.

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[1] The Stored-Grain Insects Laboratory is one of the field stations of the Stored-Product Insects Section, Biological Sciences Branch, Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

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BACKGROUND AND PURPOSE OF STUDY

Emphasis during recent years on grain sanitation has stressed the necessity for a rapid and simple method of determining the amount of larval infestation in wheat (commonly termed internal infestation). Various methods are available to the trained technician, but they are not in general suitable for use by commercial grain handlers. Investigations of separation of infested from noninfested wheat by flotation were conducted at Manhattan, Kans., 1952-54, and the results are reported here.

Frankenfeld (4) [2/] developed the acid fuchsin stain method for detecting hidden infestation in wheat. The fuchsin stains the gelatinous plugs which cover the punctures in the kernels through which the eggs were deposited. The degree of internal infestation can then be estimated from the number of plugs observed.

Apt (2) found that wheat kernels with holes by which weevils have emerged can be segregated from sound wheat by a flotation method in which wheat samples are submerged in a solution of ferric nitrate. The solution does not flow into the hole to fill up the void left by the emerged adult, and the trapped air floats the kernel. Determining the number of infested kernels per 100-gram sample was formerly the method advocated by the Food and Drug Administration (8) for establishing whether wheat met the requirements for freedom from weevil infestation.

Another relatively efficient method is the cracking-flotation technique (5). Kernels of wheat are rough ground or cracked sufficiently to release the immature forms of the weevils, which are then segregated in solutions of alcohol and gasoline. This method requires use of the microscope to identify the insects or their heads.

The most efficient method of determining the degree of internal infestation in wheat to date is use of the X-ray (7, 9). Radiographs are made from a sample of wheat and these are scanned for infested kernels. Various techniques such as the soda straw technique (3) have been used to make examination of the negatives easier.

Another method of detection is the sodium hydroxide gelatinization process (1) wherein wheat kernels are boiled in a solution of sodium hydroxide until the more advanced stages of internal infestation become visible (6).

Limitations common to the foregoing methods are that they are time consuming, expensive, technical, or not adapted for field use.

Earlier studies (10) had proved that there is a detectable loss in weight of wheat kernels infested with the rice weevil after only 1 week of larval feeding.

2/ Numbers in parentheses refer to Literature Cited, p. 5.

Since the density of wheat is fairly constant it seemed logical that infested kernels could be separated from sound kernels by using the weight factor. The immersion of wheat in a solution or solutions of controlled specific gravity appeared to offer the most feasible method of separating the wheat kernels of different weights.

There were two objectives in this study. The first was to determine whether the range of the density of sound kernels of wheat overlapped the range of the density of kernels infested with the rice weevil. The second objective was to determine whether, in case the first phase of the study showed an overlapping of the ranges, a multiple separation might be accomplished by the use of two solutions of different specific gravities.

TECHNIQUES AND MATERIALS

The density of hard red winter wheat, the type most common in the Kansas area, is about 1.4. After some experimentation, sodium silicate solution ($Na_2Si_3O_7$) was selected as a material that could be easily adjusted to specific gravities below 1.4. This material, commonly known as water glass, is readily available. The specific gravity of the solution is adjusted by the addition of water. Doubtless there are other materials also suitable for use.

When a second solution was needed which could be adjusted to specific gravities below 1.4, and which would not be miscible with sodium silicate and water, a solution of methyl chloroform and deodorized kerosene was selected. Hydrolysis at room temperatures was negligible so that mixtures of sodium silicate and methyl chloroform remained nearly stable. Further testing is necessary to determine whether hydrolysis or specific gravity changes occur after prolonged use of these solutions.

An X-ray unit especially designed for the radiographic inspection of grain samples was used to check the exact percentage of internal infestation of all the grain samples, and also of the kernels separated by flotation.

PROCEDURE

In the first phase of the study, solutions of sodium silicate were prepared, their specific gravity ranging from 1.050 to 1.350 in steps of 0.05 between 1.050 and 1.100, of 0.01 between 1.100 and 1.200, and of 0.05 between 1.250 and 1.350. Samples of hard red winter wheat with a 12-percent moisture content and infested with all stages of the rice weevil (Sitophilus oryza (L.)) were immersed in solutions at each designated specific gravity. Each subsample was then washed, dried, and X-rayed, and an exact count of the infested kernels in each part was made. Only kernels of normal size and shape were considered in making the determinations in the surface (floating) layer.

In the second phase of the study, samples of infested wheat having test weights of 56, 58, 60, and 62 pounds per bushel, were tempered to moisture contents of 10, 12, and 14 percent for each test weight. Samples of each lot were immersed in a 2-layered, nonmiscible combination of a sodium silicate solution with a specific gravity of 1.160, floating on a methyl chloroform-deodorized kerosene solution with a specific gravity of 1.30. A specific gravity of 1.160 of sodium silicate was selected as one which would give a reliable separation, and still allow a broad margin of variability both in procedure and in wheat characteristics.

RESULTS

By immersing samples in sodium silicate solutions ranging in specific gravity from 1.050 to 1.350, varying degrees of separation of weevil-infested from noninfested wheat were obtained (table 1).

At the lower part of the range, about 50 to 70 percent of the infested kernels were floated off the grain samples with no sound kernels floating. At all specific gravities between 1.050 and 1.190 the floating layer contained only infested kernels, and no sound kernels. The proportion of infested kernels that appeared in the floating layer increased until all infested ones floated at 1.350. However, at this point, many lightweight sound kernels floated also; 56 percent of the floating layer at 1.350 was composed of sound kernels.

The degree of separation resulting from immersion in the 2-layered combination of samples of wheat varying in weight and moisture content is presented in table 2. The 1.300 specific gravity solution of methyl chloroform and deodorized kerosene floated the kernels with early stages of infestation which sank in the 1.160 specific gravity solution of sodium silicate.

There did not appear to be an outstanding relationship between the degree of separation and the test weight or the moisture content. With three exceptions, the top floating layer contained only infested kernels. Nearly all of the floating kernels contained advanced stages of larvae. The middle layer contained a mixture of kernels infested with early stage larvae and lightweight sound kernels. The bottom layer was composed mostly of sound kernels. Figure 1 presents a view of a typical separation.

ANALYSIS OF RESULTS

These studies indicate that an absolute separation by flotation of infested from noninfested kernels probably will not be possible, but flotation may be used to indicate the presence of hidden infestation quite accurately.

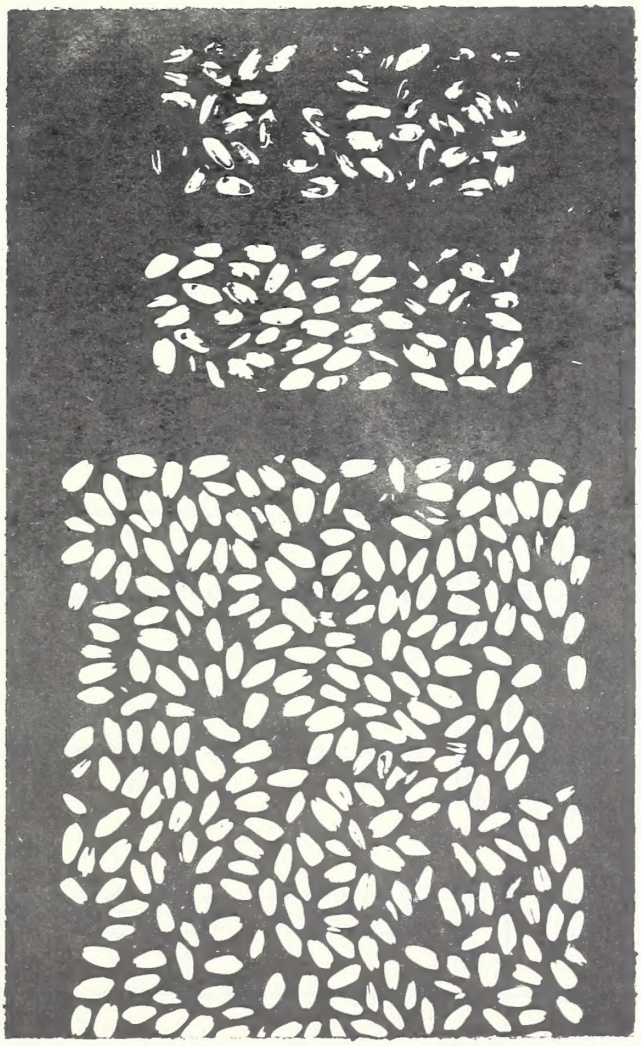

Figure 1.—Radiograph of a typical separation of infested and noninfested kernels. The top layer shows the kernels floated by sodium silicate; the next layer is floated by methyl chloroform-deodorized kerosene. The remainder are kernels that have sunk to the bottom.

Table 1.--The degree of separation between noninfested and weevil-infested wheat attained by immersion in sodium silicate solutions of various specific gravities

Specific gravity of solution	Kernels in sample	Noninfested kernels			Infested kernels			Percentage floating kernels infested
		Total	Floating		Total	Floating		
			Actual	Percentage		Actual	Percentage	
	Number	Number	Number	Percent	Number	Number	Percent	Percent
1.050 . .	623	531	0	0	92	40	43.5	100
1.100 . .	553	453	0	0	100	48	48.0	100
1.110 . .	496	412	0	0	84	42	50.0	100
1.120 . .	461	369	0	0	92	50	56.0	100
1.130 . .	455	370	0	0	85	51	60.0	100
1.140 . .	444	367	0	0	77	50	64.9	100
1.150 . .	551	452	0	0	99	71	71.7	100
1.160 . .	337	276	0	0	61	35	57.4	100
1.170 . .	368	289	0	0	79	52	65.8	100
1.180 . .	364	285	0	0	79	54	68.4	100
1.190 . .	421	360	0	0	61	47	77.0	100
1.200 . .	276	227	1	0.4	49	35	71.4	97.2
1.250 . .	390	339	35	10.3	51	34	66.7	49.3
1.300 . .	392	306	36	11.8	86	82	95.3	69.5
1.350 . .	178	119	76	63.9	59	59	100.0	43.7

Table 2.--The degree of separation between noninfested and weevil-infested wheat of 4 test weights and 3 moisture contents, attained by immersion in a nonmiscible combination of sodium silicate solution of 1.160 specific gravity floating on a methyl chloroform-deodorized kerosene solution of 1.300 specific gravity

Test weight and moisture content	Kernels in sample	Noninfested kernels				Infested kernels				Percentage of kernels infested in		
		Total	Percentage			Total	Percentage			Top layer	Middle layer	Bottom layer
			Floating in--		Sinking to bottom		Floating in--		Sinking to bottom			
			Top layer	Middle layer			Top layer	Middle layer				
	Number	Number	Percent	Percent	Percent	Number	Percent	Percent	Percent	Percent	Percent	Percent
Test weight												
56 pounds												
Moisture content												
10 percent . .	479	402	0	34.8	65.2	77	66.2	19.5	14.2	100	9.7	4.0
12 percent . .	389	341	0.9	65.7	33.4	48	83.3	14.6	2.1	93	3.0	0.9
14 percent . .	422	283	.4	53.4	46.3	139	84.1	13.7	2.2	99.2	11.1	2.2
58 pounds												
Moisture content												
10 percent . .	453	414	0	13.8	86.7	39	74.4	20.5	5.1	100	12.3	.5
12 percent . .	411	337	0	25.2	74.8	74	85.1	12.2	2.7	100	9.5	.8
14 percent . .	373	300	0	54.3	45.7	73	87.7	9.6	2.7	100	4.1	1.4
60 pounds												
Moisture content												
10 percent . .	358	287	0	3.1	96.9	71	73.2	18.3	8.5	100	59.1	2.1
12 percent . .	319	240	0	12.9	87.1	79	48.1	36.7	1.5	100	48.3	5.4
14 percent . .	300	243	0	47.3	52.7	57	70.1	28.1	1.8	100	12.2	.8
62 pounds												
Moisture content												
10 percent . .	452	369	.3	8.4	91.3	83	67.5	20.5	12.0	98.2	35.5	2.9
12 percent . .	373	303	0	11.9	88.1	70	67.1	27.1	5.7	100	34.5	1.5
14 percent . .	340	243	0	8.2	91.8	97	84.5	7.2	8.2	100	23.1	3.5

When wheat was submerged in a solution with a specific gravity considerably below that of sound wheat, 50 percent or more of the kernels with internal infestation were separated from the sample by flotation in the range between 1.050 and 1.190. From radiographic examination it was determined that these kernels contained advanced stages of larvae, which is logical since their weight would be decreased to a greater extent than where small larvae were involved. Furthermore, no lightweight sound kernels appeared in the floating layer in this range. If most commercial wheat, therefore, is similar in respect to the range of specific gravity of its kernels, then it appears that it would be possible to separate that portion of the infestation in any sample that contains mature or nearly mature larvae. For this purpose the single solution would be adequate since no additional information would apparently be gained from a 3-layer separation. Although the exact degree of internal infestation cannot be determined by this method, an indication of the general severity of infestation can be gained on the basis that if more than one kernel contains advanced-stage larvae, this fact would be evidenced by floating kernels.

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